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Nettastomella japonica Yokoyama in North America and notes on the Pholadidae

By RUTH D. TURNER

The genus *Nettastomella* is an aberrant and little known genus of the family Pholadidae closely related to the genus *Jouannetia.* At the time this family was monographed (Turner 1955) only *Nettastomella rostrata* Valenciennes was known to occur on the west coast of North America. Recently we have received specimens of *Nettastomella japonica* Yokoyama from Masset Inlet, Masset Island, in the Queen Charlotte Islands, British Columbia. This species was formerly known only from Japan. Mr. Peter Hensen collected the first living Canadian specimens at the mouth of the Watum River in Masset Inlet in the summer of 1957 where they were boring into soft sandstone at the low tide level. At the suggestion of Dr. D. B. Quayle of the Biological Station at Nanaimo, British Columbia, the specimens were sent to me for study. These specimens were sufficient to prove the identity of the species and to point out the fact that *N. japonica* differed from other members of the genus in being inequivalve. It was necessary, however, to have preserved material in order to describe fully the species and to modify the definition of the genus *Nettastomella.* Mr. Hensen kindly made a special effort to satisfy this need and I wish to express my appreciation for his aid.

The genus *Nettastomella* has always been characterized as being bilaterally symmetrical throughout life. In the young stage there is a large pedal gape but in the adult stage a partial calcareous callum is produced on the anterior margin of

the valves, the remainder of the pedal gape being closed by a membranous periostracal callum. The siphonoplax is equal on both valves, being short and divergent or long and acuminate. There is only a partial calcareous covering for the anterior adductor muscle which is equal on both valves and there are no accessory dorsal plates.

These characters readily and definitely separate this genus from *Jouannetia* which is characterized by being bilaterally symmetrical in the young stage but inequilateral in the adult stage. In this genus the pedal gape is closed by a large calcareous callum which is much larger on the left valve than on the right, the siphonoplax is produced on the right valve only and there is a small mesoplax which is displaced by the greater production of the dorsal extension of the callum over the anterior adductor muscle on the left valve. (See Plate 53.)

These two genera have always been considered to be closely related because, in the young stage, the shells are indistinguishable and because both lack apophyses. When preserved specimens of *N. japonica* were studied it was evident that these genera were even more closely related, as this species has characters which are shared by both. The incomplete calcareous callum of *N. japonica* as well as its lack of a mesoplax relates it to *Nettastomella*. However, the calcareous portion of the callum is much wider on the left valve than on the right and the siphonoplax is produced only on the right valve, characters which would place it in the genus *Jouannetia*. As shown in plates 50 to 52 there is a close resemblance between *Nettastomella* and *Jouannetia* in the arrangement of such organs as the gills, the adductor muscles and the siphons. In addition, the anatomy of the digestive tract of both *N. rostrata* and *N. japonica* is very similar to that illustrated for *Jouannetia cumingii* Sowerby by Egger (1887; pl. 2, fig. 65).

At the present time it seems best to retain both *Nettastomella* and *Jouannetia* at the generic level based on the differences in the callum and the siphonoplax and the presence of a rudimentary mesoplax in *Jouannetia*. However, if further intergrades are found it may be necessary to reduce *Nettastomella* Carpenter 1864 to a subgenus of *Jouannetia* des Moulins 1828. It is difficult to attempt any evolutionary arrangement of the Pholadidae at present as the fossil record is very incom-

plete and even many living species are known only from their shells. Only three genera of the Pholadidae, *Jouannetia*, *Nettastomella* and *Xylophaga* lack apophyses and of these *Jouannetia* has a complete calcareous callum, *Nettastomella* has a partial calcareous callum and *Xylophaga* lacks a callum. The first two are rock borers while all species in *Xylophaga* are wood borers. It is possible that these three groups arose from a common pholad-like ancestor before the apophyses developed or that they came from a common ancestor which had lost the apophyses. Though less likely, it is also possible that the apophyses were lost independently. Conversely, of these three genera, *Jouannetia* and *Xylophaga* have a mesoplax while it is lacking in *Nettastomella*. Further anatomical and developmental studies as well as additional fossil data are needed to resolve many problems in this family.

Though the genus *Nettastomella* was fully treated in the monograph of the Pholadidae (Turner 1955, pp. 141–145) a redescription of the genus is given here because of the changes made necessary by the discovery of living *N. japonica*. Full descriptions of the two species found on the west coast of North America are also included for ease in their comparison.

Genus **Nettastomella** *Carpenter*

Netastoma Carpenter 1864, Report British Association Advancement of Science for 1863, p. 637 (type species, *Netastoma darwinii* 'Sowerby' Carpenter); non *Nettastoma* Rafinesque 1810.

Nettastomella Carpenter 1865, Proc. Zoological Society London, p. 202 [new name for *Netastoma* Carpenter non *Nettastoma* Rafinesque]; Hertlein and Strong 1950, Zoologica **35**:247; Turner 1955, Johnsonia **2**:141.

Netastoma Carpenter. Vokes 1956, Journal of Paleontology **30**:768.*

Type species, *Netastoma darwinii* 'Sowerby' Carpenter 1864 [= *Nettastomella rostrata* Valenciennes non *darwinii* Sowerby], monotypic.

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* When discussing the effects of the Copenhagen Decisions of the International Commission on Zoological Nomenclature in defining the limits of generic homonymy, Vokes pointed out that *Netastoma* Carpenter is not preoccupied by *Nettastoma* Rafinesque. Also according to the International Code of Zoological Nomenclature (1961) Article 56a, two names are not considered homonyms if differing in one letter. However, *Nettastomella* has been used for this genus ever since it was introduced by Carpenter in 1865 and for the sake of stability it seems best to continue to use Carpenter's second name rather than to go back to a name which was in use for only a single year.

Shells small to moderate in size, bilaterally symmetrical and widely gaping anteriorly in the young stage. Valves divided by an umbonal-ventral constriction, the anterior portion triangular in outline and sculpture by imbricate concentric ridges and radial ribs; the posterior portion rounded and sculptured with concentric ridges and growth lines. In the adult stage the shells may be equivalve or inequivalve. The anterior gape is only partially closed by the calcareous portion of the callum, the main portion of the callum being composed of a periostracal substance. The calcareous portion of the callum is laid down as a narrow band anterior to the imbricated area and may be sculptured with thin high flutes or simply marked by growth lines. The calcareous portion of the callum may be produced equally on both valves or may be much wider on the left valve than on the right. The siphonoplax may be produced equally on both valves or only on the right valve; it may be short to long and straight or diverging. Apophyses and dorsal plates are lacking. The foot atrophies in the adult.

There are only three species known in this genus, *N. darwinii* Sowerby from Uruguay, Argentina and Chile, *N. rostrata* Valenciennes in the Eastern Pacific and *N. japonica* from the Northern Pacific.

Nettastomella japonica *Yokoyama*

Plate 47; Plate 48, fig. 2; Plate 50

Jouannetia japonica Yokoyama 1920, Journal College of Science, Imperial University of Tokyo **39,** no. 6, p. 105, pl. 7, fig. 1 (Fossil, Yokosuka Zone, Otsu [in Yokosuka, Kanagawa Perf.], Honshu, Japan).

Nettastomella japonica Yokoyama. Habe 1955, Publications from the Akkeshi Marine Biological Station, Sapporo, Japan, no. 4, p. 24, pl. 4, fig. 9; pl. 7, fig. 3; Taki and Habe 1955, Illustrated Catalogue of Japanese Shells **2,** no. 2, p. 14, pl. 2, figs. 3–4.

Description. Shell reaching about 24 mm. in length and inequivalve in the adult stage. In the young stage the valves are fragile, equivalve, beaked and widely gaping anteriorly and closed posteriorly. The valves are divided into two distinct parts by an umbonal-ventral constriction though no true sulcus is formed. Anterior portion triangular in outline and sculptured with numerous high, thin, concentric ridges and weak radial ribs. Rounded imbrications are formed where the radial ribs cross the ridges. Posterior portion sculptured by thin con-

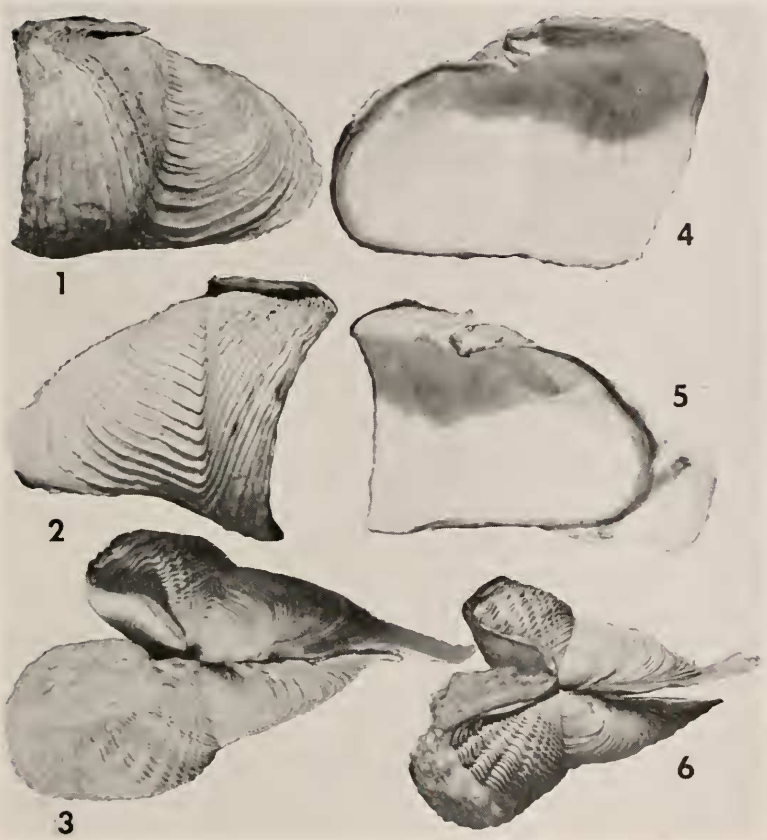

Plate 47

Nettastomella japonica Yokoyama, Masset Inlet, Masset Island, Queen Charlotte Islands, British Columbia.

Fig. 1. External view of left valve showing the wide calcareous callum.

Fig, 2. External view of left valve showing the narrow calcareous callum which is produced mainly near the ventral margin, and the siphonoplax.

Figs. 3 and 6. Dorsal views of apposed valves showing the inequivalve condition.

Fig. 4. Internal view of left valve showing the covering of the anterior adductor muscle produced by the extension of the callum dorsally.

Fig. 5. Internal view of the right valve showing the siphonoplax.

(All about 2.3×.)

centric flutes which are continuations of those of the anterior portion. They are highest near the umbonal-ventral constriction. Umbos prominent, located near the anterior one-third of the valve. The umbonal reflection narrow and free or appressed. In the adult the shell becomes very inequivalved. The calcareous portion of the callum is greatly produced on the left valve, usually becoming much wider than the anterior portion of the valve. This is continued dorsally over the umbonal reflection and covers the left half of the anterior adductor muscle. On the right valve the calcareous portion of the callum is narrow and produced only near the ventral margin. The calcareous portion of the callum is sculptured with thin flutes. The remainder of the pedal gape is closed with a periostracal covering over the muscular mantle which extends between the valves. In the young specimens there is a small opening in the mantle for the protrusion of the foot but this is almost completely closed in the fully adult animal. Siphonoplax a simple rounded prolongation which may reach half the length of the valve on the right valve but only slightly produced or lacking on the left valve. There are no other accessory plates. Periostracum thin and light straw in color.

Interior of the valve white and shining. Posterior adductor muscle scars deeply impressed and set high on the posterior slope. Anterior adductor muscle scars extending over the umbonal reflection. Ventral adductor muscle scar lightly impressed and located at the base of the umbonal-ventral ridge. Pallial line irregularly marked along the anterior margin of the valves extending posteriorly to the posterior adductor muscle dorsally and to the ventral adductor at the ventral end of the umbonal-ventral ridge. Pallial sinus not marked. Apophyses lacking. Siphons combined in a single sheath, the basal portion covered with a rather heavy, medium to dark brown periostracal sheath, the distal portion with a thin light tan sheath. Just behind the openings the combined siphons are surrounded by a collar bearing small papillae. The excurrent siphon in the preserved specimens studied appears to be slightly longer than the incurrent siphon. The siphons may be extended well beyond the end of the siphonoplax or contracted within the shell. Foot large, rounded and truncate in young specimens, atrophied in the adult.

21 mm.	15 mm.	(left valve)	Masset, Queen Charlotte Islands, B.C.
18	15	(right valve)	" " "
19.3	16.6	(young specimen)	Straits of Juan de Fuca, Washington

Types. The holotype of *Jouannetia japonica* Yokoyama is probably in the collection of the Imperial University, Tokyo, Japan. The type locality is Yokosuka Zone, Lower Musashimo, Otsu, Yokosuka, Kanagawa Prefecture, Japan.

Remarks. At the time *N. japonica* was described it was known only as a fossil occurring in the Yokosuka Zone of the Lower Musashimo (Pliocene) at Otsu, Miura Peninsula, Honshu, Japan. It was later recorded living at Akkeshi Bay, Hokkaido (Habe 1955) as well as from the north coast of Honshu off the Noto Peninsula in 305 meters and off Sado Island in 117 meters (Taki and Habe 1955). The occurrence of this species to the north and in the colder waters of the Japan Sea agrees with the statement made by Yokoyama when he discussed the fossil fauna at Otsu. "It is noteworthy" he said "that, while there are many species which now only live north of the fossil localities, there is not a single one which lives exclusively south of them." This was a cold water assemblage containing many species not found in the Tokyo area today. The occurrence of *N. japonica* at Masset in the Queen Charlotte Islands is only a slight extension of the range to the north but is a new record for the North American continent and it is another species added to the growing list of those known to be common to northern Japan, the Aleutian arc and the west coast of Canada.

The specimens received from Masset are almost identical in size and appearance to those figured by Habe and though readily distinguished from typical *rostrata* of California there was a possibility that they could be large, abnormal specimens of that species. However, through the kindness of Dr. I. MacT. Cowan of the University of British Columbia, specimens of both *N. japonica* and *N. rostrata* collected in the vicinity of Vancouver were made available for study. Though the specimens of both species were about equal in size they were readily identified. Consequently there is no doubt that there are two clearly defined species of *Nettastomella* on the west coast

Plate 48

Fig. 1. *Nettastomella rostrata* Carpenter from Whites Point, San Pedro, California. Specimen *in situ* showing the extension of the siphonoplax to the opening of the burrow at the surface (3×).

Fig. 2. *Nettastomella japonica* Yokoyama from Masset Inlet, Masset Island, British Columbia. Specimen *in situ* showing the posterior end of the valves only, the burrow being much deeper than the length of the shell. The edge of the right hand side of the burrow was outlined in ink on the photograph so that it would show clearly in the plate (2×).

Plate 48

of North America and both of them occur in the Puget Sound area.

Nettastomella japonica is found boring into blue clay and friable sandstone from near or just below low tide line probably out to depths of about 150 fathoms. Unfortunately it is not known if the specimens recorded from deep water were living at the time they were collected. The anterior end of the burrow is smoothly rounded but it is not lined with a calcareous deposit nor is there a chimney at the posterior end. The animals bore to a depth of two to three times the length of the shell but it is doubtful that they move up and down in their burrows for the tunnels reduce sharply in size toward the opening and the diameter is not sufficient to allow much movement other than that of boring. Nothing is known of the life history and means of dispersal of this species.

See also *Remarks* under *N. rostrata.*

Range. Though this species is actually recorded from only a very few localities it probably can be found in suitable habitats from the Noto Peninsula, Honshu, Japan, north through the Aleutian Islands and then south on the west coast of Canada to Puget Sound.

Specimens examined. BRITISH COLUMBIA: Masset Inlet, Masset Island, Queen Charlotte Islands (P. Hensen); Stanley Park, Vancouver (I. MacT. Cowan). WASHINGTON: *Albatross,* station 3450, about 5 miles NE of Cape Flattery, Straits of Juan de Fuca (48°26′50″ N; 124°39′35″ W) in 151 fathoms (USNM).

Nettastomella rostrata *Valenciennes*
Plate 48, fig. 1; Plate 49; Plate 51

Pholas rostrata Valenciennes 1845 [in] Abel du Petit-Thouars, Voyage Autour du Monde sur la Frégate La Venus. Atlas de Zoologie, Mollusques, pl. 24, fig. 4 [name listed on plate; no locality given]; Lamy 1921, Bulletin Museum National d'Histoire Naturelle, Paris **27**:182 (Monterey, California).

Nettastomella darwinii 'Sowerby' Carpenter 1865, Proc. Zoological Society London, p. 202 (Monterey and San Diego [California]; Vancouver [British Columbia]).

Nettastomella rostrata Valenciennes. Turner 1955, Johnsonia **3**:145, pl. 87.

Description. Shell reaching about 20 mm. (about $\frac{3}{4}$ inch) in length, equivalve in the young and adult stage, fragile, beaked

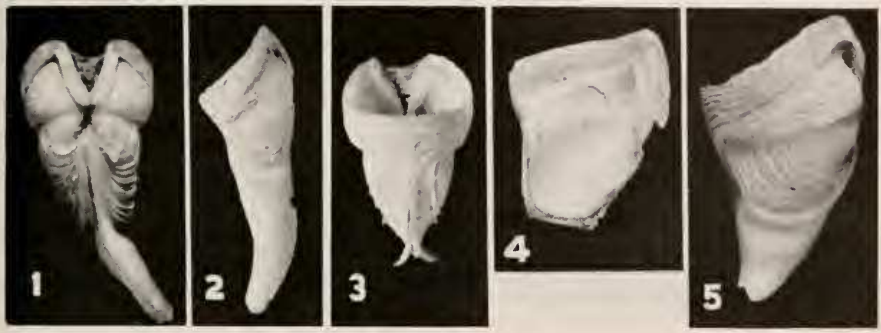

Plate 49

Nettastomella rostrata Valenciennes

Fig. 1. San Diego, California. Dorsal view of the adult specimen showing the siphonoplax and the calcareous portion of the callum which is equal on both valves.

Fig. 2. San Pedro, California. External view of the left valve showing the siphonoplax and callum.

Figs. 3–4. Laguna, California. Fig. 3. Ventral view of a young specimen just beginning to produce the siphonoplax. Fig. 4. Internal view of the right valve showing the cavity formed by the extension of the callum dorsally to cover the anterior adductor muscle. The siphonoplax has been broken off in this specimen.

Fig. 5. San Pedro, California. External view of left valve showing sculpturing on the callum and the free umbonal reflection. (All $2\frac{1}{2}\times$.)

(From Turner 1955, Johnsonia **3,** Plate 87.)

Explanation of figures used on anatomical illustrations, Plates 50–52.

1. Anterior adductor muscle.
2. Central pore of the periostracal portion of the callum.
3. Periostracal portion of the callum.
4. Thickened muscular anterior margin of the mantle.
5. Mantle.
6. Shell.
7. Posterior adductor muscle.
8. Excurrent siphon.
9. Siphonoplax.
10. Siphonal retractor muscle.
11. Incurrent siphon.
12. Labial palps.
13. Foot.
14. Visceral mass.
15. Inner demibranch of gill.
16. Outer demibranch of gill.
17. Intestine.
18. Closed mantle of adult.
19. Edge of calcareous callum.

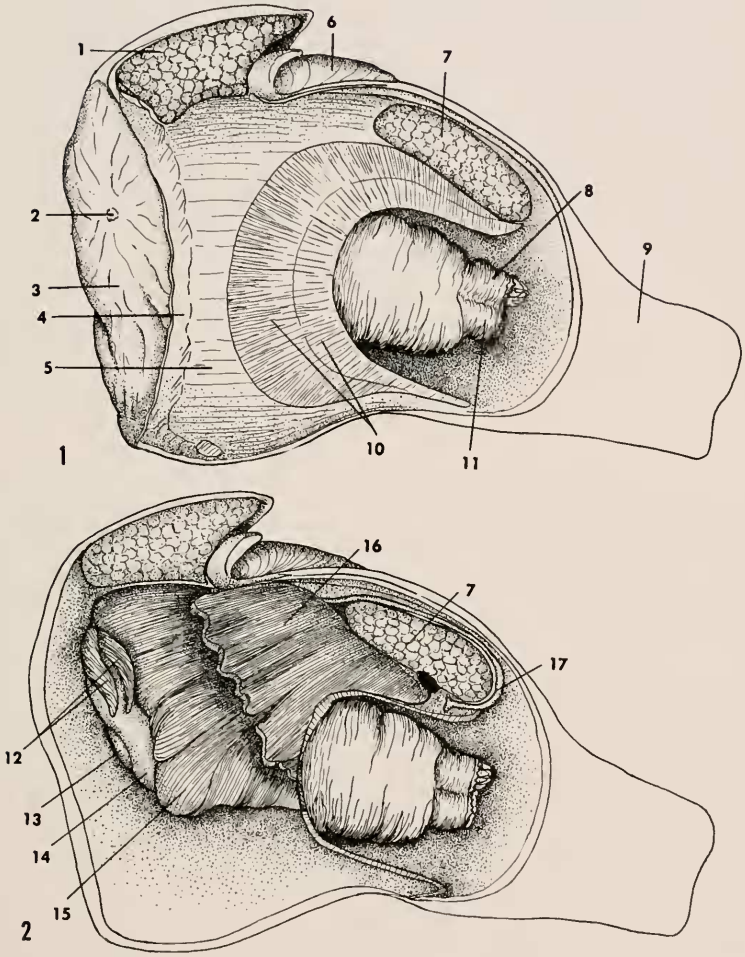

Plate 50

Nettastomella japonica Yokoyama from Masset Inlet, Masset Island, Queen Charlotte Islands, British Columbia.

Fig. 1. Specimen with left valve removed.

Fig. 2. Specimen with left valve and the left lobe of the mantle removed.

Note the greater width of the siphonal retractor muscle of this species which bores to depth several times the length of the shell.

and widely gaping anteriorly in the young stage, closed posteriorly. Shell divided into two areas by a marked umbonal-ventral constriction though no true sulcus is formed. Anterior portion triangular in outline and sculptured with numerous thin, high concentric ridges and weak radial ribs. Rounded imbrications are formed where the radial ribs cross the ridges. Posterior portion sculptured with thin, high concentric flutes which are continuations of the ridges on the anterior portion. Umbos prominent, located near the anterior third of the shell. Umbonal reflection narrow and free. In the adult stage the narrow calcareous portion of the callum is produced equally on both valves as a narrow band which extends along the anterior margins and dorsally over the umbos to enclose partially the anterior adductor muscle. The callum is fragile and sculptured with high thin flutes. The remainder of the pedal gape is closed by a periostracal callum covering the muscular mantle which extends between the valves, only a minute pore remaining open in the fully adult animal. In the young stage there is a small opening in the mantle for the protrusion of the foot but this is almost completely closed in the adult. The siphonoplax varies in length and width depending upon the age of the animal and the depth to which it is boring. In young specimens it may be very short and broad and may be reflected outwardly, but as the specimen grows the siphonoplax elongates, becoming acuminate and often irregular in shape to fit the contours of the burrow. There are no other accessory plates. Interior of valves white and glazed. Posterior adductor muscle scar oval in outline and set high on the posterior slope. Anterior adductor muscle scar extending over the umbonal reflection. Ventral adductor muscle scar lightly impressed and located at the base of the umbonal-ventral ridge. Pallial sinus extending anteriorly to the umbonal-ventral ridge. Apophyses lacking. Siphons white, slightly papillose at the posterior end, and with a thin pale yellowish periostracal sheath only at the base. They may be extended a short distance beyond the siphonoplax or contracted completely within the shell. Foot large rounded and truncate in young specimens; atrophied in the adult.

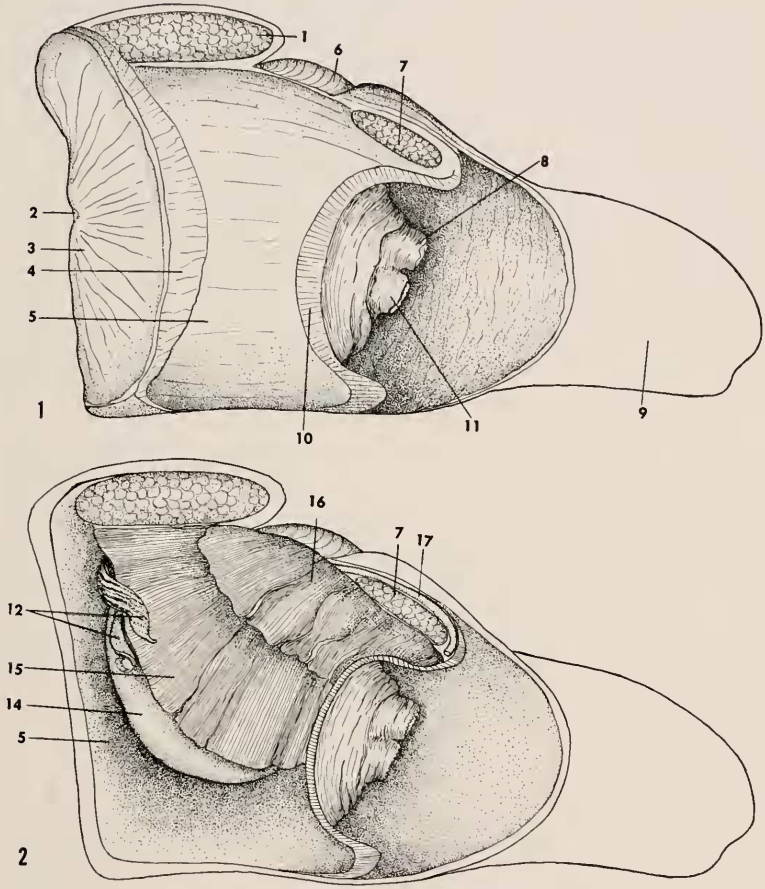

Plate 51

Nettastomella rostrata Valenciennes from White Point, San Pedro, California.

Fig. 1. Specimen with left valve removed.

Fig. 2. Specimen with left valve and left lobe of the mantle removed.

Note the proportionately smaller posterior adductor muscle and the narrow siphonal retractor muscle of this species, the siphonoplax of which extends to the surface.

length	height	
12.5 mm.	12.0 mm.	White Point, San Pedro, California
8.2	5.5	San Pedro, California
13.5	6.5	Pender Island, Vancouver, British Columbia

Types. The holotype of *P. rostrata* Valenciennes is in the Muséum National d'Histoire Naturelle, Paris. The type locality is Monterey, California.

Remarks. Adult specimens of *Nettastomella rostrata* may be readily differentiated from *N. japonica* by their bilateral symmetry and smaller size. The young stages of the two species, however, are almost impossible to distinguish. *Nettastomella rostrata* is a warmer water species and its occurrence in the Puget Sound area is still difficult to explain for there is no record of this species between Bolinas, California and British Columbia. This does not appear to be due to the lack of collecting for there are numerous records of other pholads such as *Penitella penita* Conrad and *Penitella gabbi* Tryon which live in similar habitats. The specimen sent by Dr. Cowan, though small, is quite typical and there are two lots in the United States National Museum which were not included under 'Specimens Examined' in my previous paper because it was thought the generalized locality Puget Sound was in error. This species bores into blue clay or soft rock and the siphonoplax extends to the surface as shown in Plate 46, fig. 1.

Range. Puget Sound and from Bolinas, California south to off Cedros Island, Baja California, Mexico.

Specimens examined. BRITISH COLUMBIA: Puget Sound (USNM); South Pender Island (I. MacT. Cowan). CALIFORNIA and MEXICO (see Turner 1955, p. 145).

Diplothyra curta *Sowerby*

Pholas curta Sowerby 1834, Proceedings Zoological Society London, p. 71 (Isle of Lions, Province of Veragua, Colombia [Isla Leones, Golfo de Nontijo, Province of Veraguas, Panama]).

Diplothyra curta Sowerby. Turner 1955, Johnsonia **3**:121, pl. 72.

This little known species has generally been thought to bore only into soft stone. However, Mrs. Faye Howard of Santa

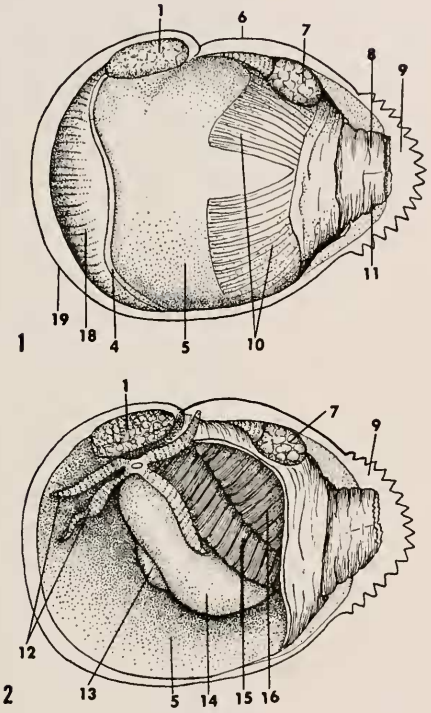

Plate 52

Jouannetia globulosa Quoy and Gaimard (after Fischer 1860, Journal de Conchyliologie **8**, pl. 15, figs. 6–7 under the name of *Jouannetia globosa* Sowerby) included here for easy comparison of the gross anatomy of *Jouannetia* and *Nettastomella*.

Barbara, California has found *Diplothyra curta* boring into the shells of the black murex, *Muricanthus negritus* Philippi, and a species of clam belonging to the genus *Chione,* as well as into coquina rock and shale. At San Felipe, Baja California, they were found in a calcareous shale along with specimens of *Lithophaga, Hiatella* and *Diplodonta* at the extreme low tide level. Specimens received from Mr. E. P. Chace of San Diego, California were boring into the spire of a murex which was covered by an encrusting calcareous bryozoan and worm tubes. These specimens had extended their burrows above the surface of the shell as oval crystalline structured pipes to keep from being smothered by the encrusting growth. In this small piece of shell (about 30 mm. in diameter) there were eight specimens of *D. curta,* two of them paralleling each other so closely that the anterior ends of their burrows had come together. I am most grateful to Mrs. Howard and Mr. Chace for sending us this interesting material.

Specimens examined. MEXICO: 18 miles N of San Felipe, Baja California (F. Howard); Punta Peñasco, Sonora (F. Howard; E. P. Chace); Puertecito, Sonora (F. Howard; E. P. Chace). [For additional records see Turner 1955.]

Penitella gabbi *Tryon*

Zirfaea gabbi Tryon 1863, Proceedings Academy Natural Sciences Philadelphia, p. 10, pl. 1, fig. 1 (Coast of Japan? [Monterey, California]).
Penitella gabbi Tryon. Turner 1955, Johnsonia **3**:85, pls. 52–54.

Specimens of this species received from Mr. Peter Hensen from Masset, Queen Charlotte Islands, British Columbia are most interesting because they are nearly twice as large as any previously recorded. The average sized specimen is about 45 mm. in length and the largest known to me was 55.5 mm. The measurements of the Masset specimens are as follows.

length	height	
93 mm.	50 mm.	adult specimen
90	53.5	" "
89.5	45.5	" "
85	47.5	young specimen

Though *Penitella gabbi* is known to reach Alaska, this record from Masset is an addition to the scanty records from the west coast of Canada.

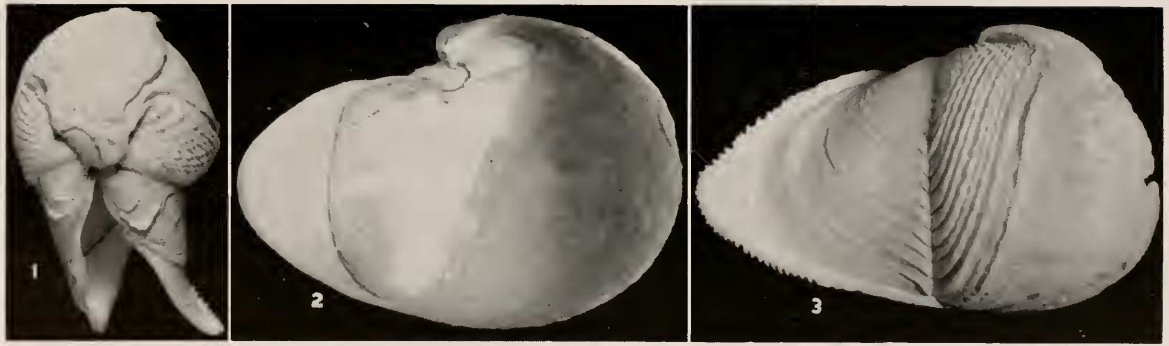

Plate 53

Jouannetia pectinata Conrad

Fig. 1. Dorsal view of the paratype showing the greatly enlarged, overlapping callum, the small mesoplax which has been displaced by the growth of the callum, and the pectinate siphonoplax of the right valve.

Fig. 2. Internal view of the left valve of the holotype showing the tremendous callum, the small posterior adductor muscle scar, the small chondrophore and the lack of the apophysis.

Fig. 3. External view of the right valve of the holotype showing the much smaller callum of this valve and the pectinate siphonoplax. (All $1\frac{1}{3}\times$.)

This species occurs from Baja California to Peru.

(From Turner 1955, Johnsonia **3,** Plate 83 — included here for ease in comparing *Jouannetia* and *Nettastomella.*)

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